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ABSTRACT:

The present invention provides a green colored, infrared and ultraviolet absorbing glass article having a luminous transmittance of up to 60 percent. The composition of the glass article uses a standard soda-lime-silica glass base composition and additionally iron, cobalt, selenium, and chromium, and optionally titanium, as infrared and ultraviolet radiation absorbing materials and colorants. The glasses of the present invention have a color characterized by a dominant wavelength in the range of about 480 to 565 nanometers, preferably about 495 to 560 nanometers, with an excitation purity of no higher than about 20 percent, preferably no higher than about 10 percent, and more preferably no higher than about 7 percent. The glass compositions may be provided with different levels of spectral performance depending on the particular application and desired luminous transmittance. In one embodiment of the invention, the glass composition of a green colored, infrared and ultraviolet radiation absorbing soda-lime-silica glass article includes a solar radiation absorbing and colorant portion consisting essentially of about 0.60 to 4 percent by weight total iron, about 0.13 to 0.9 percent by weight FeO, about 40 to 500 PPM CoO, about 5 to 70 PPM Se, about 15 to 800 PPM Cr_2O_3, and about 0.02 to 1 percent by weight TiO_2. In another embodiment of the invention, the glass composition of the article includes a solar radiation absorbing and colorant portion consisting essentially of 1 to less than 1.4 percent by weight total iron, about 0.2 to 0.6 percent by weight FeO, greater than 200 to about 500 PPM CoO, about 5 to 70 PPM Se, greater than 200 to about 800 PPM Cr_2O_3, and 0 to about 1 percent by weight TiO_2.

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(54) Green privacy glass

(57) The present invention provides a green colored, infrared and ultraviolet absorbing glass article having a luminous transmittance of up to 60 percent. The composition of the glass article uses a standard soda-lime-silica glass base composition and additionally iron, cobalt, selenium, and chromium, and optionally titanium, as infrared and ultraviolet radiation absorbing materials and colorants. The glasses of the present invention have a color characterized by a dominant wavelength in the range of about 480 to 565 nanometers, preferably about 495 to 560 nanometers, with an excitation purity of no higher than about 20 percent, preferably no higher than about 10 percent, and more preferably no higher than about 7 percent. The glass compositions may be provided with different levels of spectral performance depending on the particular application and desired luminous transmittance.

In one embodiment of the invention, the glass composition of a green colored, infrared and ultraviolet radiation absorbing soda-lime-silica glass article includes a solar radiation absorbing and colorant portion consisting essentially of about 0.60 to 4 percent by weight total iron, about 0.13 to 0.9 percent by weight FeO, about 40 to 500 PPM CoO, about 5 to 70 PPM Se, about 15 to 800 PPM Cr_2O_3, and about 0.02 to 1 percent by weight TiO_2. In another embodiment of the invention, the glass composition of the article includes a solar radiation absorbing and colorant portion consisting essentially of 1 to less than 1.4 percent by weight total iron, about 0.2 to 0.6 percent by weight FeO, greater than 200 to about 500 PPM CoO, about 5 to 70 PPM Se, greater than 200 to about 800 PPM Cr_2O_3, and 0 to about 1 percent by weight TiO_2.

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Description

The invention refers to a green colored, infrared and ultraviolet absorbing glass having a base glass portion and a solar radiation absorbing colorant portion to control the luminous transmittance (LTA), ultraviolet transmittance (TSUV), total solar infrared transmittance (TSIR) and the total solar energy transmittance (TSET).

This invention relates particularly to a tinted, green colored soda-lime-silica glass having a low luminous transmittance that makes it highly desirable for use as a privacy glazing in vehicles, such as the side and rear windows in vans. In particular, the glass has a luminous transmittance of 60 percent or less, preferably between about 10 to 40 percent. As used herein, the term "green colored" is meant to include glasses that have a dominant wavelength of about 480 to 565 nanometers (nm) and may be characterized as green blue, green yellow or green gray in color. In addition, the glass of the present invention generally exhibits lower infrared and ultraviolet radiation transmittance when compared to typical green glasses used in automotive applications. The glass is also compatible with float glass manufacturing methods.

Various dark tinted, infrared and ultraviolet radiation absorbing glass compositions are known in the art. The primary colorant in typical dark tinted automotive privacy glasses is iron, which is usually present in both the Fe_2O_3 and FeO forms. Some glasses use cobalt, selenium and, optionally, nickel in combination with iron to further control infrared and ultraviolet radiation and color, for example as disclosed in U.S.-A-4,873,206 to Jones; 5,278,108 to Cheng et al.; 5,308,805 to Baker et al.; and 5,393,593 to Gulotta et al., and EP-A-0 705 800. Others also include chromium with this combination of colorants as disclosed in U.S.-A-4,104,076 to Pons; 4,339,541 to Dela Ruye; 5,023,210 to Krumwiede et al; and 5,352,640 to Combes et al.; EP-A-0 536 049; FR-A-2,331,527 and CA-A-2,148,954. Still, other glasses may include additional materials, such as disclosed in WO 96/00194, which teaches the inclusion of fluorine, zirconium, zinc, cerium, titanium and copper in the glass composition and requires that the sum of the alkaline earth oxides be less than 10 wt.% of the glass.

In producing infrared and ultraviolet radiation absorbing glasses, the relative amounts of iron and other additives must be closely monitored and controlled within an operating range to provide the desired color and spectral properties. It would be desirable to have a dark tinted green colored glass that may be used as a privacy glazing for vehicles to complement the green colored glasses typically used in automobiles that exhibits superior solar performance properties and is compatible with commercial float glass manufacturing techniques.

The present invention provides a green colored, infrared and ultraviolet absorbing glass article having a luminous transmittance of up to 60 percent at at least one thickness in the range of 1.8 to 5.0 mm. Referred reference thicknesses for the spectral properties are between 3,91 mm and 4.06 mm. The composition of the glass article uses a standard soda-lime-silica glass base composition and additionally iron, cobalt, selenium, and chromium, and optionally titanium, as infrared and ultraviolet radiation absorbing materials and colorants. The glasses of the present invention preferably have a color characterized by a dominant wavelength in the range of about 480 to 565 nanometers, more preferably about 495 to 560 nanometers, with an excitation purity of no higher than about 20%, preferably no higher than about 10%, and more preferably no higher than about 7%. The glass compositions may be provided with different levels of spectral performance depending on the particular application and desired luminous transmittance.

In one embodiment of the invention, the glass composition of a green colored, infrared and ultraviolet radiation absorbing soda-lime-silica glass article includes a solar radiation absorbing and colorant portion consisting essentially of about 0.60 to 4 percent by weight total iron, about 0.13 to 0.9 percent by weight FeO, about 40 to 500 PPM CoO, about 5 to 70 PPM Se, about 15 to 800 PPM Cr_2O_3, and about 0.02 to 1 percent by weight TiO_2. In another embodiment of the invention, the glass composition of the article includes a solar radiation absorbing and colorant portion consisting essentially of 1 to less than 1.4 percent by weight total iron, about 0.2 to 0.6 percent by weight FeO, greater than 200 to about 500 PPM CoO, about 5 to 70 PPM Se, greater than 200 to about 800 PPM Cr_2O_3, and 0 to about 1 percent by weight TiO_2.

DETAILED DESCRIPTION OF THE INVENTION

The base glass of the present invention, that is, the major constituents of the glass without infrared or ultraviolet absorbing materials and/or colorants, which are the object of the present invention, is commercial soda-lime-silica glass characterized as follows:

	Weight Percent
SiO_2	66-75
Na_2O	10-20
CaO	5-15
MgO	0-5
Al_2O_3	0-5
K_2O	0-5

As used herein, all "weight percent (wt. %)" values are based on the total weight of the final glass composition.

To this base glass, the present invention adds infrared and ultraviolet radiation absorbing materials and colorants in the form of iron, cobalt, selenium, chromium and, optionally, titanium. As disclosed herein, iron is expressed in terms of Fe_2O_3 and FeO, cobalt is expressed in terms of CoO, selenium is expressed in terms of elemental Se, chromium is expressed in terms of Cr_2O_3 and titanium is expressed in terms of TiO_2. It should be appreciated that the glass compositions disclosed herein may include small amounts of other materials, for example melting and refining aids, tramp materials or impurities. It should be further appreciated that in one embodiment of the invention, small amounts of additional materials may be included in the glass to improve the solar performance of the glass as will be discussed later in more detail.

The iron oxides in a glass composition perform several functions. Ferric oxide, Fe_2O_3, is a strong ultraviolet radiation absorber and operates as a yellow colorant in the glass. Ferrous oxide, FeO, is a strong infrared radiation absorber and operates as a blue colorant. The total amount of iron present in the glasses disclosed herein is expressed in terms of Fe_2O_3 in accordance with standard analytical practice but that does not imply that all of the iron is actually in the form of Fe_2O_3. Likewise, the amount of iron in the ferrous state is reported as FeO, even though it may not actually be present in the glass as FeO. In order to reflect the relative amounts of ferrous and ferric iron in the glass compositions disclosed herein, the term "redox" shall mean the amount of iron in the ferrous state (expressed as FeO) divided by the amount of total iron (expressed as Fe_2O_3). Furthermore, unless stated otherwise, the term "total iron" in this specification shall mean total iron expressed in terms of Fe_2O_3 and the term "FeO" shall mean iron in the ferrous state expressed in terms of FeO.

Se is an ultraviolet and infrared radiation absorbing colorant that imparts a pink or brown color to soda-lime-silica glass. Se may also absorb some infrared radiation and its use tends to decrease redox. CoO operates as a blue colorant and does not exhibit any appreciable ultraviolet or infrared radiation absorbing properties. Cr_2O_3 imparts a green color to the glass and helps control the final glass color. It is believed that the chromium may also provide some ultraviolet radiation absorption. TiO_2 is an ultraviolet radiation absorber that operates as a colorant imparting a yellow color to the glass composition. A proper balance between the iron, i.e. ferric and ferrous oxides, chromium, selenium, cobalt and optionally titanium content is required to obtain the desired green colored privacy glass with the desired spectral properties.

The glass of the present invention may be melted and refined in a continuous, large-scale, commercial melting operation and formed into flat glass sheets of varying thicknesses by the float method in which the molten glass is supported on a pool of molten metal, usually tin, as it assumes a ribbon shape and is cooled. It should be appreciated that as a result of forming the glass on molten tin, measurable amounts of tin oxide may migrate into surface portions of the glass on the side that was in contact with the tin. Typically, a piece of float glass has an SnO_2 concentration of at least 0.05 to 2 wt.% in the first 25 microns below the surface of the glass that was in contact with the tin. Typical background levels of SnO_2 may be as high as 30 parts per million (PPM).

The melting and forming arrangements used to produce the glass compositions of the present invention include, but are not limited to a conventional, overhead fired continuous melting operation, as is well known in the art, or a multi-stage melting operation, as disclosed in U.S.-A-4,381,934 to Kunkle et al.; 4,792,536 to Pecoraro et al. and 4,886,539 to Cerutti et al. If required, a stirring arrangement may be employed within the melting and/or forming stages of the glass production operation to homogenize the glass in order to produce glass of the highest optical quality.

Tables 1, 2 and 3 illustrate examples of glass compositions which embody the principles of the present invention. The examples in Tables 1 and 2 are computer modeled compositions generated by a glass color and spectral performance computer model developed by PPG Industries, Inc. The examples in Table 3 are actual experimental laboratory melts. The spectral properties shown for Tables 1 and 3 are based on a reference thickness of 4.06 mm (0.160 inches) and those in Table 2 are based on a reference thickness of 3.91 mm (0.154 inches). For comparison purposes, the

spectral properties of the examples may be approximated at different thicknesses using the formulas disclosed in U.S.-A-4,792,536. Only the iron, cobalt, selenium, chromium and titanium portions of the examples are listed in the tables. With respect to the transmittance data provided in the tables, the luminous transmittance (LTA) is measured using C.I.E. standard illuminant "A" with a 2° observer over the wavelength range 380 to 770 nanometers and glass color, in terms of dominant wavelength and excitation purity, is measured using C.I.E. standard illuminant "C" with a 2° observer, following the procedures established in ASTM E308-90. The total solar ultraviolet transmittance (TSUV) is measured over the wavelength range 300 to 400 nanometers, total solar infrared transmittance (TSIR) is measured over the wavelength range 720 to 2000 nanometers, and total solar energy transmittance (TSET) is measured over the wavelength range 300 to 2000 nanometers. The TSUV, TSIR and TSET transmittance data are calculated using Parry Moon air mass 2.0 direct solar irradiance data and integrated using the Trapezoidal Rule, as is known in the art.

The optical properties reported in Tables 1 and 2 are the expected properties of a glass having a base glass composition and colorants, generally as discussed herein, based upon the absorption coefficients of the glass' constituents, assuming that the glass is homogeneous throughout and is manufactured by a conventional float glass process, as is well known in the art.

The information provided in Table 3 is based on experimental laboratory melts having approximately the following batch components:

cullet A	125 gm
cullet B	22.32 gm
cullet C	8.93 gm
rouge	0.32 gm
Cr_2O_3	0.0461 gm
TiO_2	0.3-0.6 gm
Se	0.0037-0.0073 gm
graphite	0.015 gm

The cullets used in the melts included varying amounts of iron, cobalt, selenium, chromium and/or titanium. More specifically, cullet A included 0.811 wt.% total iron, 0.212 wt.% FeO, 101 PPM CoO, 17 PPM Se, 8 PPM Cr_2O_3, and 0.02 wt.% TiO_2. Cullet B included 1.417 wt.% total iron, 0.362 wt.% FeO, 211.25 PPM CoO, 25 PPM Se, and 7.5 PPM Cr_2O_3. Cullet C included 0.93 wt.% total iron, 0.24 wt.% FeO, 6 PPM Cr_2O_3, and 0.02 wt.% TiO_2. In preparing the melts, the ingredients were weighed out and mixed. It is believed that the material was then placed in a 4-inch platinum crucible and heated to 1427°C (2600°F) for 30 minutes and then heated to 1454°C (2650°F) for 1 hour. Next, the molten glass was fritted in water, dried, put in a 2-inch platinum crucible and reheated at 1454°C (2650°F) for at least 1 hour. The molten glass was then poured out of the crucible to form a slab and annealed. Samples were cut from the slab and ground and polished for analysis. The chemical analysis of the glass compositions was determined using a RIGAKU 3370 X-ray fluorescence spectrophotometer. The FeO content was determined using wet chemistry techniques, as is well known in the art. The spectral characteristics of the glass were determined on annealed samples using a Perkin-Elmer Lambda 9 UV/VIS/NIR spectrophotometer prior to tempering the glass or prolonged exposure to ultraviolet radiation, which will effect the spectral properties of the glass.

The following is representative of the basic oxides of the particular experimental melts disclosed in Table 3, which also fall within the base glass composition discussed earlier:

SiO_2	70-72 wt.%
Na_2O	12-14 wt.%
CaO	8-10 wt.%
MgO	3-4 wt.%
Al_2O_3	0.1-0.6 wt.%
K_2O	0.01-0.15 wt.%

The analysis of these melts also showed that the glasses included about 0.081 wt.% MnO_2. It is presumed that the MnO_2 entered into the glass melt as part of the cullet.

TABLE 1

	Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5	Ex. 6	Ex. 7	Ex. 8	Ex. 9	Ex. 10	Ex. 11	Ex. 12
FeO (wt.%)	0.4320	0.5580	0.7240	0.4775	0.5225	0.5143	0.5670	0.6545	0.6110	0.4725	0.6938	0.5980
Total iron (wt.%)	1.920	1.860	1.810	1.910	1.900	1.870	1.890	1.870	1.880	1.890	1.850	1.840
Model redox	0.2250	0.3000	0.4000	0.2500	0.2750	0.2750	0.3000	0.3500	0.3250	0.2500	0.3750	0.3250
Cr2O3 (wt.%)	0.0365	0.0350	0.0350	0.0365	0.0365	0.0340	0.0365	0.0370	0.0365	0.0350	0.0370	0.0355
CoO (wt.%)	0.0391	0.0356	0.0310	0.0377	0.0364	0.0370	0.0351	0.0326	0.0338	0.0379	0.0314	0.0344
Se (wt.%)	0.0047	0.0050	0.0054	0.0048	0.0049	0.0048	0.0050	0.0052	0.0051	0.0047	0.0053	0.0050
TiO2 (wt.%)		0.1800	0.2400			0.4900				0.3400		0.4400
LTA (%)	5.02	5.04	5.05	5.05	5.06	5.08	5.08	5.10	5.10	5.12	5.12	5.13
TSUV (%)	2.48	2.88	3.58	2.62	2.77	2.59	2.94	3.29	3.11	2.52	3.51	2.95
TSIR (%)	7.28	3.84	1.73	5.76	4.59	4.78	3.68	2.41	2.97	5.91	2.00	3.16
TSET (%)	6.33	4.42	3.18	5.50	4.85	4.96	4.33	3.60	3.93	5.61	3.37	4.05
DW (nm)	551.02	550.90	550.96	551.29	550.79	550.61	550.68	550.52	550.92	550.76	550.81	550.64
Pe (%)	3.58	3.57	3.62	3.72	3.72	3.85	3.76	3.85	3.84	3.86	3.83	3.98

TABLE 1 (cont.)

	Ex. 13	Ex. 14	Ex. 15	Ex. 16	Ex. 17	Ex. 18	Ex. 19	Ex. 20	Ex. 21	Ex. 22	Ex. 23	Ex. 24
FeO (wt.%)	0.7360	0.4298	0.6825	0.6405	0.3860	0.3860	0.3750	0.3750	0.8750	0.3750	0.8125	0.3750
Total iron (wt.%)	1.840	1.910	1.820	1.830	1.930	1.930	1.500	1.500	3.500	1.500	3.250	1.500
Model redox	0.4000	0.2250	0.3750	0.3500	0.2000	0.2000	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500
Cr2O3 (wt.%)	0.0370	0.0340	0.0340	0.0345	0.0375	0.0330	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250
CoO (wt.%)	0.0302	0.0390	0.0320	0.0330	0.0398	0.0400	0.0450	0.0400	0.0220	0.0220	0.0220	0.0350
Se (wt.%)	0.0054	0.0046	0.0052	0.0051	0.0045	0.0044	0.0027	0.0027	0.0027	0.0060	0.0027	0.0027
TiO2 (wt.%)		0.2600	0.4500	0.3900		0.3900	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
LTA (%)	5.13	5.15	5.16	5.19	5.20	5.28	6.54	7.80	8.59	8.73	9.20	9.33
TSUV (%)	3.72	2.41	3.29	3.16	2.40	2.24	6.17	6.21	1.07	2.86	1.32	6.24
TSIR (%)	1.64	7.38	2.11	2.58	9.28	9.29	9.94	9.99	0.89	9.98	1.18	10.04
TSET (%)	3.16	6.44	3.44	3.73	7.50	7.54	9.18	9.65	3.64	9.09	4.10	10.20
DW (nm)	551.01	550.93	550.70	550.93	550.63	550.86	478.05	479.92	549.82	581.29	549.90	482.49
Pe (%)	3.86	3.70	3.89	3.92	3.76	3.89	30.19	23.61	18.23	38.27	16.69	16.75

TABLE 1 (cont.)

	Ex. 25	Ex. 26	Ex. 27	Ex. 28	Ex. 29	Ex. 30	Ex. 31	Ex. 32	Ex. 33	Ex. 34	Ex. 35	Ex. 36
FeO (wt.%)	0.375	0.75	0.225	0.6875	0.375	0.175	0.375	0.625	0.5625	0.375	0.225	0.5
Total iron (wt.%)	1.5000	3.0000	0.9000	2.7500	1.5000	0.7000	1.5000	2.5000	2.2500	1.5000	0.9000	2.0000
Model redox	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
Cr2O3 (wt.%)	0.0250	0.0250	0.0250	0.0250	0.0250	0.0210	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250
CoO (wt.%)	0.0220	0.0220	0.0450	0.0220	0.0220	0.0450	0.0300	0.0220	0.0220	0.0220	0.0400	0.0220
Se (wt.%)	0.0053	0.0027	0.0017	0.0027	0.0046	0.0011	0.0027	0.0027	0.0027	0.0039	0.0017	0.0027
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
LTA (%)	9.74	9.86	10.49	10.56	10.90	10.99	11.19	11.33	12.15	12.23	12.42	13.04
TSUV (%)	3.39	1.62	18.98	2.00	4.01	26.80	6.28	2.49	3.11	4.74	19.09	3.91
TSIR (%)	10.02	1.58	23.31	2.11	10.06	30.76	10.09	2.85	3.88	10.10	23.41	5.30
TSET (%)	9.54	4.64	19.61	5.29	10.08	24.75	10.84	6.09	7.09	10.72	20.37	8.36
DW (nm)	579.72	549.97	474.57	550.01	577.57	473.07	487.02	550.02	549.99	574.14	475.74	549.87
Pe (%)	31.58	15.12	43.48	13.51	24.63	50.78	9.78	11.87	10.21	17.48	37.70	8.51

TABLE 1 (cont.)

	Ex. 37	Ex. 38	Ex. 39	Ex. 40	Ex. 41	Ex. 42	Ex. 43	Ex. 44	Ex. 45	Ex. 46	Ex. 47	Ex. 48
FeO (wt.%)	0.6	0.175	0.375	0.5625	0.375	0.375	0.525	0.375	0.375	0.4375	0.4875	0.375
Total iron (wt.%)	1.500	0.700	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.750	1.500	1.500
Model redox	0.4000	0.2500	0.2500	0.3750	0.2500	0.2500	0.3500	0.2500	0.2500	0.2500	0.3250	0.2500
Cr2O3 (wt.%)	0.0250	0.0210	0.0800	0.0250	0.0250	0.0700	0.0250	0.0250	0.0600	0.0250	0.0250	0.0500
CoO (wt.%)	0.0220	0.0400	0.0220	0.0220	0.0250	0.0220	0.0220	0.0220	0.0220	0.0220	0.0220	0.0220
Se (wt.%)	0.0027	0.0011	0.0027	0.0027	0.0027	0.0027	0.0027	0.0032	0.0027	0.0027	0.0027	0.0027
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
LTA (%)	13.10	13.12	13.23	13.40	13.45	13.53	13.70	13.78	13.85	14.00	14.02	14.17
TSUV (%)	9.03	26.97	6.09	8.50	6.31	6.13	8.00	5.62	6.18	4.96	7.54	6.22
TSIR (%)	3.24	30.90	10.05	3.89	10.14	10.07	4.69	10.14	10.09	7.31	5.66	10.11
TSET (%)	7.78	25.64	10.89	8.22	11.61	11.10	8.74	11.50	11.31	10.00	9.37	11.54
DW (nm)	488.02	474.18	554.18	489.76	502.78	553.79	492.18	566.66	553.27	549.62	496.03	552.58
Pe (%)	11.44	45.13	12.49	9.38	3.22	11.14	7.32	10.21	9.78	6.79	5.31	8.43

TABLE 1 (cont.)

	Ex. 49	Ex. 50	Ex. 51	Ex. 52	Ex. 53	Ex. 54	Ex. 55	Ex. 56	Ex. 57	Ex. 58	Ex. 59	Ex. 60
FeO (wt.%)	0.4500	0.3750	0.4125	0.2250	0.3750	0.3750	0.3750	0.3750	0.3750	0.3750	0.2948	0.3750
Total iron (wt.%)	1.500	1.500	1.500	0.900	1.500	1.500	1.500	1.500	1.500	1.500	1.310	1.500
Model redox	0.3000	0.2500	0.2750	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2250	0.2500
Cr2O3 (wt.%)	0.0250	0.0400	0.0250	0.0250	0.0300	0.0250	0.0250	0.0250	0.0250	0.0250	0.0280	0.0250
CoO (wt.%)	0.0220	0.0220	0.0220	0.0350	0.0220	0.0220	0.0220	0.0220	0.0220	0.0220	0.0235	0.0220
Se (wt.%)	0.0027	0.0027	0.0027	0.0017	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027	0.0028	0.0027
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.2000	0.2000	0.8000	0.7000	0.6000	0.5000	0.4000		0.3000
LTA (%)	14.34	14.51	14.68	14.74	14.86	14.90	14.93	14.95	14.97	14.99	15.01	15.01
TSUV (%)	7.11	6.27	6.71	19.20	6.31	5.44	5.58	5.72	5.87	6.02	7.47	6.18
TSIR (%)	6.86	10.14	8.34	23.52	10.16	10.17	10.17	10.17	10.17	10.17	15.69	10.17
TSET (%)	10.12	11.77	11.04	21.26	12.02	11.97	12.00	12.03	12.05	12.08	15.28	12.11
DW (nm)	503.82	551.62	525.32	477.06	550.13	558.49	557.46	556.28	554.91	553.31	550.91	551.42
Pe (%)	3.46	7.08	2.97	31.54	5.72	8.18	7.66	7.14	6.61	6.09	3.66	5.57

TABLE 1 (cont.)

	Ex. 61	Ex. 62	Ex. 63	Ex. 64	Ex. 65	Ex. 66	Ex. 67	Ex. 68	Ex. 69	Ex. 70	Ex. 71	Ex. 72
FeO (wt.%)	0.3750	0.3750	0.3750	0.3493	0.3810	0.3250	0.4960	0.4650	0.3750	0.2600	0.3750	0.2880
Total iron (wt.%)	1.500	1.500	1.500	1.270	1.270	1.300	1.240	1.240	1.500	1.300	1.500	1.280
Model redox	0.2500	0.2500	0.2500	0.2750	0.3000	0.2500	0.4000	0.3750	0.2500	0.2000	0.2500	0.2250
Cr2O3 (wt.%)	0.0250	0.0250	0.0250	0.0255	0.0260	0.0280	0.0290	0.0260	0.0250	0.0270	0.0250	0.0260
CoO (wt.%)	0.0220	0.0220	0.0220	0.0222	0.0212	0.0226	0.0178	0.0189	0.0220	0.0245	0.0220	0.0240
Se (wt.%)	0.0027	0.0027	0.0027	0.0029	0.0030	0.0029	0.0033	0.0032	0.0027	0.0027	0.0027	0.0027
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.3000	0.1500			0.2000	0.1000	0.1300	0.0200	0.4800
LTA (%)	15.04	15.04	15.04	15.04	15.05	15.05	15.05	15.06	15.06	15.07	15.08	15.08
TSUV (%)	6.34	6.34	6.34	7.81	8.35	7.82	10.25	9.45	6.50	7.10	6.63	6.98
TSIR (%)	10.17	10.17	10.17	11.67	9.85	13.30	5.43	6.36	10.17	19.02	10.17	16.29
TSET (%)	12.14	12.14	12.14	13.09	12.09	13.99	9.57	10.11	12.17	17.12	12.20	15.62
DW (nm)	549.10	549.10	549.10	550.99	550.72	550.89	551.07	550.60	546.28	550.76	543.54	550.58
Pe (%)	5.04	5.04	5.04	3.66	3.57	3.69	3.79	3.60	4.53	3.54	4.12	3.82

TABLE 1 (cont.)

	Ex. 73	Ex. 74	Ex. 75	Ex. 76	Ex. 77	Ex. 78	Ex. 79	Ex. 80	Ex. 81	Ex. 82	Ex. 83	Ex. 84
FeO (wt.%)	0.4410	0.4375	0.3200	0.3548	0.4688	0.4095	0.4960	0.3840	0.2640	0.4128	0.3750	0.3375
Total iron (wt.%)	1.260	1.250	1.280	1.290	1.250	1.260	1.240	1.280	1.320	1.270	1.500	1.500
Model redox	0.3500	0.3500	0.2500	0.2750	0.3750	0.3250	0.4000	0.3000	0.2000	0.3250	0.2500	0.2250
Cr2O3 (wt.%)	0.0290	0.0260	0.0260	0.0290	0.0290	0.0260	0.0250	0.0290	0.0280	0.0290	0.0200	0.0250
CoO (wt.%)	0.0193	0.0197	0.0230	0.0217	0.0185	0.0205	0.0182	0.0208	0.0242	0.0200	0.0220	0.0220
Se (wt.%)	0.0032	0.0031	0.0028	0.0029	0.0032	0.0030	0.0032	0.0030	0.0027	0.0031	0.0027	0.0027
TiO2 (wt.%)		0.3000	0.3500			0.3900	0.4400				0.2000	0.2000
LTA (%)	15.09	15.09	15.09	15.09	15.11	15.14	15.14	15.15	15.16	15.16	15.22	15.40
TSUV (%)	9.38	8.87	7.42	8.20	9.82	8.34	9.35	8.59	7.18	8.99	6.36	5.98
TSIR (%)	7.19	7.33	13.67	11.32	6.24	8.48	5.44	9.69	18.60	8.33	10.18	12.44
TSET (%)	10.59	10.66	14.20	12.91	10.05	11.32	9.58	12.02	16.92	11.26	12.27	13.49
DW (nm)	550.53	550.77	550.65	550.53	550.80	550.87	550.70	551.11	550.86	550.82	547.74	559.28
Pe (%)	3.77	3.79	3.76	3.79	3.80	3.95	3.93	3.89	3.70	3.85	4.37	7.45

TABLE 1 (cont.)

	Ex. 85	Ex. 86	Ex. 87	Ex. 88	Ex. 89	Ex. 90	Ex. 91	Ex. 92	Ex. 93	Ex. 94	Ex. 95	Ex. 96
FeO (wt.%)	0.3750	0.3750	0.1750	0.3000	0.3750	0.3750	0.3750	0.2250	0.3120	0.2990	0.2860	0.2990
Total iron (wt.%)	1.500	1.500	0.700	1.500	1.500	1.500	1.500	0.900	1.200	1.150	1.100	1.100
Model redox	0.2500	0.2500	0.2500	0.2000	0.2500	0.2500	0.2500	0.2500	0.2600	0.2600	0.2600	0.2720
Cr2O3 (wt.%)	0.0250	0.0100	0.0210	0.0250	0.0005	0.0250	0.0250	0.0250	0.0230	0.0280	0.0320	0.0320
CoO (wt.%)	0.0220	0.0220	0.0350	0.0220	0.0220	0.0200	0.0220	0.0300	0.0196	0.0200	0.0201	0.0198
Se (wt.%)	0.0025	0.0027	0.0011	0.0027	0.0027	0.0027	0.0020	0.0017	0.0025	0.0024	0.0025	0.0025
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.0280	0.0280	0.0280	0.0280
LTA (%)	15.58	15.59	15.72	15.78	15.95	16.20	17.04	17.54	18.03	18.05	18.02	18.06
TSUV (%)	6.65	6.40	27.14	5.65	6.45	6.35	7.50	19.31	9.55	10.19	10.64	10.87
TSIR (%)	10.18	10.21	31.05	15.27	10.23	10.19	10.22	23.63	11.9	12.88	13.95	12.88
TSET (%)	12.43	12.54	26.69	15.14	12.80	12.53	13.22	22.30	15.38	15.96	16.53	15.95
DW (nm)	528.36	543.24	475.35	564.59	533.25	560.22	496.92	478.60	556.5	547.3	549.7	545.6
Pe (%)	3.26	3.03	39.04	9.88	1.81	8.39	5.84	25.04	4.43	3.36	3.62	3.27

TABLE 1 (cont.)

	Ex. 97	Ex. 98	Ex. 99	Ex. 100	Ex. 101	Ex. 102	Ex. 103	Ex. 104	Ex. 105	Ex. 106	Ex. 107	Ex. 108
FeO (wt.%)	0.3750	0.1750	0.2250	0.3750	0.2250	0.2250	0.3750	0.1750	0.1750	0.2250	0.3750	0.1750
Total iron (wt.%)	1.500	0.700	0.900	1.500	0.900	0.900	1.500	0.700	0.700	0.900	1.500	0.700
Model redox	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500
Cr2O3 (wt.%)	0.0250	0.0210	0.0250	0.0250	0.0250	0.0250	0.0250	0.0210	0.0210	0.0250	0.0250	0.0210
CoO (wt.%)	0.0220	0.0300	0.0107	0.0150	0.0250	0.0107	0.0220	0.0070	0.0250	0.0107	0.0100	0.0070
Se (wt.%)	0.0015	0.0011	0.0060	0.0027	0.0017	0.0053	0.0008	0.0060	0.0011	0.0046	0.0027	0.0053
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
LTA (%)	18.68	18.88	19.28	19.57	20.92	21.12	21.31	21.65	22.73	23.19	23.68	23.86
TSUV (%)	8.46	27.31	7.87	6.39	19.42	9.14	10.02	9.26	27.48	10.62	6.42	10.85
TSIR (%)	10.25	31.19	23.35	10.25	23.73	23.46	10.29	31.12	31.34	23.57	10.30	31.22
TSET (%)	14.13	27.91	20.49	13.63	23.52	21.34	15.65	25.68	29.35	22.31	14.95	26.65
DW (nm)	491.19	476.64	583.88	568.92	480.62	582.85	487.95	585.96	478.18	581.60	572.24	585.04
Pe (%)	10.53	32.49	41.80	16.72	18.24	36.18	17.10	49.85	25.55	30.33	24.81	44.03

TABLE 1 (cont.)

	Ex. 109	Ex. 110	Ex. 111	Ex. 112	Ex. 113	Ex. 114	Ex. 115	Ex. 116	Ex. 117	Ex. 118	Ex. 119	Ex. 120
FeO (wt.%)	0.2250	0.2060	0.3185	0.2970	0.3600	0.2750	0.3263	0.3440	0.3395	0.2585	0.2925	0.2040
Total Iron (wt.%)	0.900	1.030	0.980	0.990	0.960	1.000	0.870	0.860	0.970	0.940	0.900	1.020
Model redox	0.2500	0.2000	0.3250	0.3000	0.3750	0.2750	0.3750	0.4000	0.3500	0.2750	0.3250	0.2000
Cr2O3 (wt.%)	0.0250	0.0240	0.0240	0.0240	0.0250	0.0240	0.0270	0.0280	0.0240	0.0250	0.0260	0.0235
CoO (wt.%)	0.0200	0.0170	0.0138	0.0144	0.0126	0.0150	0.0135	0.0131	0.0132	0.0155	0.0145	0.0172
Se (wt.%)	0.0017	0.0018	0.0022	0.0021	0.0023	0.0020	0.0022	0.0022	0.0022	0.0020	0.0021	0.0018
TiO2 (wt.%)	0.2000						0.3000	0.4700		0.2600	0.3100	0.2600
LTA (%)	25.01	25.01	25.04	25.06	25.07	25.08	25.08	25.08	25.08	25.08	25.09	25.09
TSUV (%)	19.53	12.29	14.95	14.39	16.20	13.84	16.42	16.44	15.57	13.87	15.07	11.78
TSIR (%)	23.84	26.16	13.98	15.73	11.18	17.75	13.41	12.18	12.48	19.46	16.12	26.47
TSET (%)	24.95	25.29	18.67	19.63	17.11	20.75	18.38	17.65	17.85	21.69	19.87	25.45
DW (nm)	483.91	550.56	551.23	551.01	550.87	551.07	550.51	550.63	550.78	550.87	550.95	550.70
Pe (%)	11.21	3.69	3.72	3.71	3.75	3.75	3.55	3.88	3.65	3.67	3.66	3.94

TABLE 1 (cont.)

	Ex. 121	Ex. 122	Ex. 123	Ex. 124	Ex. 125	Ex. 126	Ex. 127	Ex. 128	Ex. 129	Ex. 130	Ex. 131	Ex. 132
FeO (wt.%)	0.2183	0.2400	0.3800	0.2525	0.3115	0.2295	0.2760	0.2250	0.1750	0.1750	0.2250	0.4250
Total iron (wt.%)	0.970	0.960	0.950	1.010	0.890	1.020	0.920	0.900	0.700	0.700	0.900	1.700
Model redox	0.2250	0.2500	0.4000	0.2500	0.3500	0.2250	0.3000	0.2500	0.2500	0.2500	0.2500	0.2500
Cr2O3 (wt.%)	0.0230	0.0240	0.0250	0.0240	0.0270	0.0240	0.0250	0.0250	0.0210	0.0210	0.0250	0.0250
CoO (wt.%)	0.0167	0.0162	0.0120	0.0156	0.0140	0.0162	0.0150	0.0107	0.0070	0.0200	0.0107	0.0107
Se (wt.%)	0.0019	0.0019	0.0023	0.0020	0.0021	0.0019	0.0020	0.0039	0.0046	0.0011	0.0032	0.0017
TiO2 (wt.%)	0.2300	0.4200			0.4500		0.4300	0.2000	0.2000	0.2000	0.2000	0.2000
LTA (%)	25.09	25.10	25.13	25.15	25.17	25.19	25.27	25.52	26.35	27.45	28.15	28.38
TSUV (%)	12.79	12.80	16.85	13.34	15.24	12.83	14.09	12.33	12.71	27.65	14.33	9.99
TSIR (%)	24.41	21.59	10.06	20.12	14.53	22.90	17.66	23.68	31.33	31.49	23.80	8.20
TSET (%)	24.40	22.83	16.50	22.08	18.99	23.60	20.77	23.44	27.77	31.06	24.75	16.22
DW (nm)	550.83	550.53	551.00	550.49	550.57	551.12	550.65	579.95	584.02	480.17	577.51	545.94
Pe (%)	3.51	3.84	3.74	3.71	3.91	3.80	3.82	24.29	37.88	18.25	18.11	7.52

TABLE 1 (cont.)

	Ex. 133	Ex. 134	Ex. 135	Ex. 136	Ex. 137	Ex. 138	Ex. 139	Ex. 140	Ex. 141	Ex. 142	Ex. 143	Ex. 144
FeO (wt.%)	0.3750	0.4000	0.1750	0.3750	0.2250	0.3500	0.2250	0.2250	0.2250	0.3250	0.3600	0.2250
Total iron (wt.%)	1.500	1.600	0.700	1.500	0.900	1.400	0.900	0.900	0.900	1.300	0.900	0.900
Model redox	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.4000	0.2500
Cr2O3 (wt.%)	0.0250	0.0250	0.0210	0.0250	0.0250	0.0250	0.0800	0.0250	0.0700	0.0250	0.0250	0.0600
CoO (wt.%)	0.0050	0.0107	0.0070	0.0107	0.0150	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107
Se (wt.%)	0.0027	0.0017	0.0039	0.0017	0.0017	0.0017	0.0017	0.0025	0.0017	0.0017	0.0017	0.0017
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
LTA (%)	28.72	29.13	29.19	29.91	29.96	30.71	30.71	31.14	31.44	31.53	32.11	32.20
TSUV (%)	6.46	10.84	14.90	11.76	19.65	12.78	19.13	16.64	19.24	13.90	23.95	19.35
TSIR (%)	10.35	9.34	31.44	10.65	23.95	12.15	23.80	23.91	23.84	13.89	11.55	23.89
TSET (%)	16.56	17.23	29.09	18.35	26.65	19.59	25.48	26.29	25.96	20.97	20.75	26.46
DW (nm)	574.22	546.65	582.80	547.43	492.96	548.31	556.15	573.03	556.08	549.30	492.90	555.97
Pe (%)	32.55	7.16	31.42	6.80	4.27	6.44	11.87	11.83	10.56	6.07	5.63	9.24

TABLE 1 (cont.)

	Ex. 145	Ex. 146	Ex. 147	Ex. 148	Ex. 149	Ex. 150	Ex. 151	Ex. 152	Ex. 153	Ex. 154	Ex. 155	Ex. 156
FeO (wt.%)	0.3000	0.1750	0.3375	0.2250	0.3150	0.1750	0.2750	0.2250	0.2925	0.2250	0.2700	0.2500
Total Iron (wt.%)	1.200	0.700	0.900	0.900	0.900	0.700	1.100	0.900	0.900	0.900	0.900	1.000
Model redox	0.2500	0.2500	0.3750	0.2500	0.3500	0.2500	0.2500	0.2500	0.3250	0.2500	0.3000	0.2500
Cr2O3 (wt.%)	0.0250	0.0210	0.0250	0.0500	0.0250	0.0210	0.0250	0.0250	0.0250	0.0400	0.0250	0.0250
CoO (wt.%)	0.0107	0.0070	0.0107	0.0107	0.0107	0.0150	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107
Se (wt.%)	0.0017	0.0032	0.0017	0.0017	0.0017	0.0011	0.0017	0.0020	0.0017	0.0017	0.0017	0.0017
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
LTA (%)	32.37	32.44	32.57	32.99	33.05	33.22	33.24	33.52	33.54	33.80	34.03	34.14
TSUV (%)	15.15	17.46	23.17	19.46	22.43	27.83	16.52	18.52	21.72	19.57	21.03	18.05
TSIR (%)	15.90	31.55	13.01	23.93	14.68	31.64	18.23	24.00	16.58	23.98	18.74	20.92
TSET (%)	22.52	30.63	21.68	26.98	22.72	33.10	24.24	27.54	23.89	27.52	25.21	26.19
DW (nm)	550.42	581.19	495.48	555.80	499.55	483.52	551.73	565.70	507.34	555.55	524.51	553.17
Pe (%)	5.71	24.72	4.48	7.93	3.37	10.68	5.36	7.33	2.42	6.61	2.27	5.00

TABLE 1 (cont.)

	Ex. 157	Ex. 158	Ex. 159	Ex. 160	Ex. 161	Ex. 162	Ex. 163	Ex. 164	Ex. 165	Ex. 166	Ex. 167	Ex. 168
FeO (wt.%)	0.2475	0.2250	0.2250	0.2250	0.2250	0.2250	0.2250	0.2250	0.3038	0.2050	0.1760	0.1680
Total iron (wt.%)	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.810	0.820	0.880	0.840
Model redox	0.2750	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.3750	0.2500	0.2000	0.2000
Cr2O3 (wt.%)	0.0250	0.0300	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0270	0.0250	0.0280	0.0270
CoO (wt.%)	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0084	0.0113	0.0119	0.0122
Se (wt.%)	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0020	0.0017	0.0016	0.0016
TiO2 (wt.%)	0.2000	0.2000	0.8000	0.7000	0.6000	0.5000	0.4000	0.3000		0.2200		0.1500
LTA (%)	34.54	34.63	34.75	34.80	34.85	34.91	34.96	35.01	35.02	35.03	35.05	35.05
TSUV (%)	20.38	19.69	16.79	17.24	17.72	18.20	18.70	19.22	24.83	21.12	20.29	20.31
TSIR (%)	21.22	24.03	24.05	24.05	24.05	24.05	24.05	24.05	15.60	26.90	31.69	33.17
TSET (%)	26.70	28.08	27.94	28.01	28.08	28.15	28.23	28.30	23.83	30.05	32.59	33.42
DW (nm)	544.21	555.15	562.59	561.76	560.81	559.69	558.39	556.81	550.61	550.96	550.65	560.80
Pe (%)	3.34	5.30	7.81	7.28	6.76	6.23	5.70	5.17	3.72	3.47	3.73	3.55

TABLE 1 (cont.)

	Ex. 169	Ex. 170	Ex. 171	Ex. 172	Ex. 173	Ex. 174	Ex. 175	Ex. 176	Ex. 177	Ex. 178	Ex. 179	Ex. 180
FeO (wt.%)	0.2250	0.2250	0.2250	0.1868	0.2730	0.2550	0.2150	0.2365	0.3200	0.2250	0.2870	0.1958
Total iron (wt.%)	0.900	0.900	0.900	0.830	0.840	0.850	0.860	0.860	0.800	0.900	0.820	0.870
Model redox	0.2500	0.2500	0.2500	0.2250	0.3250	0.3000	0.2500	0.2750	0.4000	0.2500	0.3500	0.2250
Cr2O3 (wt.%)	0.0250	0.0250	0.0250	0.0270	0.0280	0.0280	0.0280	0.0280	0.0270	0.0250	0.0270	0.0280
CoO (wt.%)	0.0107	0.0107	0.0107	0.0118	0.0092	0.0097	0.0108	0.0102	0.0079	0.0107	0.0088	0.0113
Se (wt.%)	0.0017	0.0017	0.0017	0.0016	0.0019	0.0018	0.0017	0.0018	0.0020	0.0017	0.0019	0.0017
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.3200						0.1000		
LTA (%)	35.06	35.06	35.06	35.08	35.09	35.09	35.10	35.11	35.11	35.11	35.12	35.13
TSUV (%)	19.75	19.75	19.75	20.17	23.31	22.65	21.54	21.99	25.59	20.29	24.15	20.91
TSIR (%)	24.05	24.05	24.05	29.82	18.43	20.35	25.42	22.54	14.29	24.05	17.08	28.33
TSET (%)	28.37	28.37	28.37	31.58	25.39	26.45	29.23	27.65	23.15	28.45	24.69	30.81
DW (nm)	554.86	554.86	554.86	550.80	550.76	550.70	550.37	550.89	550.75	552.42	551.11	550.97
Pe (%)	4.64	4.64	4.64	3.81	3.93	3.91	3.76	3.92	3.76	4.11	3.79	3.81

TABLE 1 (cont.)

	Ex. 181	Ex. 182	Ex. 183	Ex. 184	Ex. 185	Ex. 186	Ex. 187	Ex. 188	Ex. 189	Ex. 190	Ex. 192	Ex. 192
FeO (wt.%)	0.2228	0.2250	0.2730	0.2568	0.2888	0.2430	0.3040	0.2250	0.2025	0.2250	0.1800	0.2250
Total iron (wt.%)	0.810	0.900	0.780	0.790	0.770	0.810	0.760	0.900	0.900	0.900	0.900	0.900
Model redox	0.2750	0.2500	0.3500	0.3250	0.3750	0.3000	0.4000	0.2500	0.2250	0.2500	0.2000	0.2500
Cr2O3 (wt.%)	0.0260	0.0250	0.0260	0.0265	0.0260	0.0250	0.0255	0.0200	0.0250	0.0250	0.0250	0.0250
CoO (wt.%)	0.0108	0.0107	0.0095	0.0098	0.0089	0.0104	0.0086	0.0107	0.0107	0.0100	0.0107	0.0107
Se (wt.%)	0.0017	0.0017	0.0018	0.0018	0.0019	0.0017	0.0019	0.0017	0.0017	0.0017	0.0017	0.0015
TiO2 (wt.%)	0.3200	0.0200	0.4600	0.2900	0.2700	0.4900	0.4200	0.2000	0.2000	0.2000	0.2000	0.2000
LTA (%)	35.15	35.15	35.16	35.17	35.18	35.20	35.21	35.50	35.59	35.97	36.14	36.14
TSUV (%)	21.34	20.74	22.52	22.73	24.12	20.99	24.01	19.80	19.14	19.76	18.55	20.61
TSIR (%)	24.35	24.05	18.45	20.16	16.93	21.77	15.59	24.07	27.29	24.06	31.00	24.08
TSET (%)	28.67	28.51	25.41	26.39	24.63	27.24	23.87	28.67	30.27	28.68	32.42	28.96
DW (nm)	550.59	549.96	550.81	550.78	550.91	550.73	550.79	554.47	560.86	559.34	564.72	537.17
Pe (%)	3.72	3.69	3.98	3.79	3.73	3.96	3.87	3.99	5.98	5.81	7.33	2.96

TABLE 1 (cont.)

	Ex. 193	Ex. 194	Ex. 195	Ex. 196	Ex. 197	Ex. 198	Ex. 199	Ex. 200	Ex. 201	Ex. 202	Ex. 203	Ex. 204
FeO (wt.%)	0.1750	0.2250	0.2250	0.3500	0.3250	0.1750	0.1750	0.3000	0.1750	0.2250	0.1750	0.2750
Total iron (wt.%)	0.700	0.900	0.900	1.400	1.300	0.700	0.700	1.200	0.700	0.900	0.700	1.100
Model redox	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500
Cr2O3 (wt.%)	0.0210	0.0100	0.0005	0.0210	0.0210	0.0210	0.0800	0.0210	0.0700	0.0250	0.0210	0.0210
CoO (wt.%)	0.0070	0.0107	0.0107	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0107	0.0100	0.0070
Se (wt.%)	0.0025	0.0017	0.0017	0.0011	0.0011	0.0020	0.0011	0.0011	0.0011	0.0008	0.0011	0.0011
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
LTA (%)	36.15	36.39	37.27	37.74	38.74	39.14	39.29	39.76	40.23	40.24	40.32	40.81
TSUV (%)	20.46	19.92	20.03	15.66	16.96	22.92	27.23	18.38	27.37	23.94	28.00	19.95
TSIR (%)	31.66	24.12	24.16	12.05	13.79	31.74	31.55	15.80	31.61	24.20	31.79	18.13
TSET (%)	32.46	29.28	29.89	22.48	23.95	33.97	33.23	25.58	33.86	31.25	35.55	27.40
DW (nm)	578.76	553.07	549.31	541.05	542.27	575.77	555.78	543.64	555.68	494.01	494.99	545.18
Pe (%)	17.83	2.68	1.44	5.63	5.36	12.83	11.51	5.09	10.21	6.17	3.20	4.83

TABLE 1 (cont.)

	Ex. 205	Ex. 206	Ex. 207	Ex. 208	Ex. 209	Ex. 210	Ex. 211	Ex. 212	Ex. 213	Ex. 214	Ex. 215	Ex. 216
FeO (wt.%)	0.1750	0.2500	0.1750	0.2800	0.1750	0.2625	0.2250	0.2450	0.1750	0.2250	0.2275	0.2000
Total iron (wt.%)	0.700	1.000	0.700	0.700	0.700	0.700	0.900	0.700	0.700	0.900	0.700	0.800
Model redox	0.2500	0.2500	0.2500	0.4000	0.2500	0.3750	0.2500	0.3500	0.2500	0.2500	0.3250	0.2500
Cr2O3 (wt.%)	0.0600	0.0210	0.0500	0.0210	0.0210	0.0210	0.0210	0.0210	0.0400	0.0250	0.0210	0.0210
CoO (wt.%)	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0050	0.0070	0.0070
Se (wt.%)	0.0011	0.0011	0.0011	0.0011	0.0015	0.0011	0.0011	0.0011	0.0011	0.0017	0.0011	0.0011
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
LTA (%)	41.21	41.90	42.22	42.25	42.45	42.74	43.01	43.24	43.27	43.29	43.76	44.16
TSUV (%)	27.52	21.68	27.67	32.61	25.67	31.79	23.59	31.01	27.82	19.88	30.25	25.73
TSIR (%)	31.66	20.83	31.72	17.65	31.82	19.44	23.97	21.44	31.78	24.18	23.65	27.63
TSET (%)	34.49	29.44	35.15	28.68	35.70	29.79	31.73	31.01	35.85	31.10	32.35	34.32
DW (nm)	555.53	546.93	555.32	494.20	569.54	496.90	548.91	501.21	555.00	570.22	509.20	551.16
Pe (%)	8.90	4.57	7.59	4.43	7.81	3.54	4.31	2.70	6.29	14.10	2.01	4.06

TABLE 1 (cont.)

	Ex. 217	Ex. 218	Ex. 219	Ex. 220	Ex. 221	Ex. 222	Ex. 223	Ex. 224	Ex. 225	Ex. 226	Ex. 227	Ex. 228
FeO (wt.%)	0.2100	0.1750	0.1925	0.1750	0.1750	0.2210	0.1440	0.2600	0.2380	0.2100	0.2345	0.1460
Total iron (wt.%)	0.700	0.700	0.700	0.700	0.700	0.680	0.720	0.650	0.680	0.700	0.670	0.730
Model redox	0.3000	0.2500	0.2750	0.2500	0.2500	0.3250	0.2000	0.4000	0.3500	0.3000	0.3500	0.2000
Cr2O3 (wt.%)	0.0210	0.0300	0.0210	0.0210	0.0210	0.0210	0.0240	0.0250	0.0250	0.0255	0.0215	0.0245
CoO (wt.%)	0.0070	0.0070	0.0070	0.0070	0.0070	0.0060	0.0079	0.0047	0.0053	0.0060	0.0057	0.0077
Se (wt.%)	0.0011	0.0011	0.0011	0.0011	0.0011	0.0012	0.0010	0.0013	0.0013	0.0012	0.0012	0.0010
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.8000	0.7000	0.2000	0.2000				0.3000	
LTA (%)	44.28	44.35	44.81	44.95	45.01	45.03	45.04	45.05	45.06	45.07	45.07	45.07
TSUV (%)	29.51	27.97	28.80	23.80	24.47	30.09	26.82	34.11	32.22	30.62	30.22	27.82
TSIR (%)	26.11	31.83	28.84	31.89	31.89	24.54	38.12	19.73	22.30	26.10	22.75	37.68
TSET (%)	33.83	36.57	35.46	36.68	36.77	33.15	40.43	30.51	31.90	33.96	32.14	40.25
DW (nm)	525.66	554.49	543.44	562.94	562.02	550.93	551.27	550.47	550.26	550.86	550.56	550.90
Pe (%)	2.00	4.99	2.82	6.99	6.46	3.55	3.78	3.71	3.76	3.87	3.72	3.59

TABLE 1 (cont.)

	Ex. 229	Ex. 230	Ex. 231	Ex. 232	Ex. 233	Ex. 234	Ex. 235	Ex. 236	Ex. 237	Ex. 238	Ex. 239	Ex. 240
FeO (wt.%)	0.1953	0.1750	0.1725	0.2513	0.1800	0.1750	0.2243	0.1643	0.1750	0.2475	0.2560	0.1750
Total iron (wt.%)	0.710	0.700	0.690	0.670	0.720	0.700	0.690	0.730	0.700	0.660	0.640	0.700
Model redox	0.2750	0.2500	0.2500	0.3750	0.2500	0.2500	0.3250	0.2250	0.2500	0.3750	0.4000	0.2500
Cr2O3 (wt.%)	0.0255	0.0210	0.0230	0.0255	0.0245	0.0210	0.0255	0.0245	0.0210	0.0210	0.0215	0.0210
CoO (wt.%)	0.0064	0.0070	0.0070	0.0049	0.0068	0.0070	0.0056	0.0072	0.0070	0.0054	0.0052	0.0070
Se (wt.%)	0.0011	0.0011	0.0011	0.0013	0.0011	0.0011	0.0012	0.0011	0.0011	0.0012	0.0012	0.0011
TiO2 (wt.%)		0.6000	0.1500			0.5000			0.4000	0.4200	0.5200	0.3000
LTA (%)	45.07	45.08	45.10	45.12	45.13	45.15	45.15	45.17	45.21	45.22	45.27	45.28
TSUV (%)	29.87	25.16	28.73	33.06	29.08	25.86	31.45	28.35	26.59	30.17	30.49	27.34
TSIR (%)	28.38	31.89	32.33	20.71	30.96	31.89	24.08	33.90	31.89	21.16	20.19	31.89
TSET (%)	35.20	36.86	37.40	31.04	36.65	36.96	32.90	38.24	37.05	31.29	30.75	37.15
DW (nm)	550.41	560.95	551.62	550.70	550.88	559.66	550.68	550.94	558.12	550.89	550.76	556.18
Pe (%)	3.79	5.93	3.61	3.88	3.72	5.40	3.87	3.71	4.87	3.90	4.01	4.35

TABLE 1 (cont.)

	Ex. 241	Ex. 242	Ex. 243	Ex. 244	Ex. 245	Ex. 246	Ex. 247	Ex. 248	Ex. 249	Ex. 250	Ex. 251	Ex. 252
FeO (wt.%)	0.1925	0.2070	0.1750	0.1750	0.1750	0.1620	0.1750	0.1750	0.1750	0.1575	0.1400	0.1500
Total iron (wt.%)	0.700	0.690	0.700	0.700	0.700	0.720	0.700	0.700	0.700	0.700	0.700	0.600
Model redox	0.2750	0.3000	0.2500	0.2500	0.2500	0.2250	0.2500	0.2500	0.2500	0.2250	0.2000	0.2500
Cr2O3 (wt.%)	0.0230	0.0210	0.0210	0.0210	0.0210	0.0220	0.0210	0.0200	0.0210	0.0210	0.0210	0.0210
CoO (wt.%)	0.0066	0.0064	0.0070	0.0070	0.0070	0.0075	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070
Se (wt.%)	0.0011	0.0011	0.0011	0.0011	0.0011	0.0010	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
TiO2 (wt.%)	0.2000	0.3800	0.2000	0.2000	0.2000	0.3000	0.1000	0.2000	0.0200	0.2000	0.2000	0.2000
LTA (%)	45.29	45.35	45.35	45.35	45.35	45.35	45.42	45.46	45.47	45.90	46.46	46.57
TSUV (%)	28.78	28.32	28.11	28.11	28.11	26.77	28.90	28.12	29.56	27.44	26.79	30.79
TSIR (%)	28.84	26.57	31.89	31.89	31.89	34.36	31.89	31.89	31.89	35.28	39.06	36.86
TSET (%)	35.54	34.31	37.25	37.25	37.25	38.55	37.35	37.33	37.43	39.23	41.41	40.58
DW (nm)	550.70	550.64	553.71	553.71	553.71	550.30	550.44	553.59	546.98	559.73	563.70	556.63
Pe (%)	3.77	3.80	3.82	3.82	3.82	3.71	3.29	3.69	2.87	4.84	5.88	3.57

TABLE 1 (cont.)

	Ex. 253	Ex. 254	Ex. 255	Ex. 256
FeO (wt.%)	0.1750	0.1750	0.1750	0.1750
Total iron (wt.%)	0.700	0.700	0.700	0.700
Model redox	0.2500	0.2500	0.2500	0.2500
Cr2O3 (wt.%)	0.0100	0.0210	0.0005	0.0210
CoO (wt.%)	0.0070	0.0070	0.0070	0.0050
Se (wt.%)	0.0011	0.0008	0.0011	0.0011
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.2000
LTA (%)	46.61	47.69	47.75	49.07
TSUV (%)	28.28	30.09	28.43	28.18
TSIR (%)	31.95	31.93	32.01	31.95
TSET (%)	38.11	38.53	38.89	38.50
DW (nm)	551.69	509.82	545.77	565.18
Pe (%)	2.39	2.14	1.16	7.39

TABLE 2

	Ex. 257	Ex. 258 Ex.	259	Ex. 260	Ex. 261	Ex. 262	Ex. 263	Ex. 264	Ex. 265
FeO (wt.%)	0.3232	0.2980	0.3080	0.2980	0.3500	0.2890	0.3500	0.3500	0.3080
Total iron (wt.%)	1.103	1.103	1.100	1.103	1.083	1.070	1.083	1.083	1.100
Model redox	0.2929	0.2702	0.2800	0.2702	0.3232	0.2701	0.3232	0.3232	0.2800
Cr2O3 (wt.%)	0.0302	0.0302	0.0302	0.0302	0.0293	0.0302	0.0293	0.0293	0.0302
CoO (wt.%)	0.0128	0.0125	0.0128	0.0119	0.0110	0.0119	0.0100	0.0090	0.0100
Se (wt.%)	0.0010	0.0010	0.0010	0.0009	0.0010	0.0009	0.0010	0.0010	0.0010
TiO2 (wt.%)	0.1940	0.1940	0.1940	0.1940	0.3510	0.1940	0.3510	0.3510	0.1940
LTA (%)	31.13	31.95	32.59	33.18	33.47	33.52	34.63	35.84	35.87
TSUV (%)	16.53	15.93	20.62	16.28	19.74	16.79	19.76	19.78	20.69
TSIR (%)	12.31	14.26	13.45	14.27	10.54	15.05	10.54	10.55	13.47
TSET (%)	21.38	22.72	22.93	23.23	21.37	23.84	21.74	22.12	23.98
DW (nm)	497.4	502.2	493.5	502.5	497.8	502.1	502.2	509.2	505.2
Pe (%)	6.57	5.03	6.86	5.14	5.59	5.1	4.52	3.69	3.75

TABLE 3

	Ex. 266	Ex. 267	Ex. 268	Ex. 269
FeO (wt.%)	0.3060	0.3080	0.3400	0.3500
Total iron (wt.%)	1.099	1.103	1.101	1.110
Redox	0.2790	0.2800	0.3100	0.3160
Cr2O3 (wt.%)	0.0286	0.0302	0.0288	0.0323
CoO (wt.%)	0.0128	0.0128	0.0129	0.0129
Se (wt.%)	0.0012	0.0010	0.0008	0.0007
TiO2 (wt.%)	0.3550	0.1940	0.3500	0.1940
LTA (%)	28.33	29.47	29.91	30.25
TSUV (%)	14.14	15.72	16.28	19.16
TSIR (%)	12.99	12.72	10.44	9.31
TSET (%)	19.56	20.12	19.13	18.93
DW (nm)	509.2	497.2	494.2	491.1
Pe (%)	4.06	5.59	8.89	11.88

Referring to Tables 1, 2 and 3, the present invention provides a green colored glass using a standard soda-lime-silica glass base composition and additionally iron, cobalt, selenium and chromium, and optionally titanium, as infrared and ultraviolet radiation absorbing materials and colorants. As may be seen, not all of the examples are the same color, as indicated by the dominant wavelength (DW) and excitation purity (Pe). In the present invention, it is preferred that the glass have a color characterized by a dominant wavelength in the range of about 480 to 565 nanometers, preferably

about 495 to 560 nanometers, with an excitation purity of no higher than about 20%, preferably no higher than about 10%, and more preferably no higher than about 7%. It is anticipated that the color of the glass may vary within this dominant wavelength range to provide a desired product. For example, a green blue glass may be produced at a dominant wavelength of about 485 to 515 nanometers, preferably about 490 to 510 nanometers, with an excitation purity of no higher than 10%, preferably not higher than 7%, while a green yellow glass may be produced at a dominant wavelength of about 535 to 565 nanometers, preferably about 540 to 560 nanometers, with an excitation purity of no higher than 10%, preferably not higher than 5%.

The green colored, infrared and ultraviolet radiation absorbing glasses disclosed in the present invention have a luminous transmittance (LTA) of up to 60 percent. In one particular embodiment, the glasses include about 0.6 to 4 wt.% total iron, about 0.13 to 0.9 wt.% FeO, about 40 to 500 PPM CoO, about 5 to 70 PPM Se, about 15 to 800 PPM Cr_2O_3 and 0.02 to about 1 wt.% TiO_2. In another embodiment, the glasses include about 1 to less than 1.4 wt.% total iron, about 0.2 to 0.60 wt.% FeO, greater than 200 to about 500 PPM CoO, about 5 to 70 PPM Se, greater than 200 to about 800 PPM Cr_2O_3 and 0 to about 1 wt.% TiO_2. The redox ratio for these glasses is maintained between about 0.20 to 0.40, preferably between about 0.22 to 0.35, more preferably between about 0.23 to 0.28. These glass compositions also have a TSUV of no greater than about 40%, preferably no greater than about 35%, a TSIR of no greater than about 45%, preferably no greater than about 40%, and a TSET of no greater than about 50%, preferably no greater than about 45%.

The glass compositions of the present invention may be provided with varying levels of spectral performance, depending on the particular application and desired luminous transmittance. In one embodiment of the invention, for a green colored, infrared and ultraviolet radiation absorbing glass having an LTA of less than 20% at at least one thickness in the range of 1.8 to 5.0 mm, the glass composition includes about 1 to less than 1.4 wt.% total iron; about 0.22 to 0.5 wt.% FeO, preferably about 0.3 to 0.5 wt.% FeO; greater than 200 to about 450 PPM CoO, preferably greater than 200 to about 350 PPM; about 10 to 60 PPM Se, preferably about 35 to 50 PPM; about 250 to 400 PPM Cr_2O_3, preferably about 250 to 350 PPM; and 0 to about 1 wt.% TiO_2, preferably about 0.02 to 0.5 wt.%. The glass compositions within this luminous transmittance range have a TSUV of no greater than about 30%, preferably no greater than 12%, a TSIR of no greater than about 35%, preferably no greater than about 20%, and a TSET of no greater than about 30%, preferably no greater than about 20%.

In another embodiment of the invention, for a green colored, infrared and ultraviolet radiation absorbing glass having an LTA of less than 20 to 60% at at least one thickness in the range of 1.8 to 5.0 mm, the glass composition includes about 1 to less than 1.4 wt.% total iron; about 0.25 to 0.4 wt.% FeO; greater than 200 to about 250 PPM CoO; about 10 to 30 PPM Se; greater than 200 to about 250 PPM Cr_2O_3, and about 0.02 to 0.5 wt.% TiO_2. The glass compositions within this luminous transmittance range have a TSUV of no greater than about 35%, preferably no greater than 20%, a TSIR of no greater than about 40%, preferably no greater than about 15%, and a TSET of no greater than about 45%, preferably, no greater than about 25%.

In another embodiment of the invention, for a green colored, infrared and ultraviolet radiation absorbing glass having an LTA of 20 to 60% at a reference thickness of 4.06 mm, the glass composition includes greater than 0.7 to about 2 wt.% total iron, preferably about 0.8 to 1.5 wt.%; about 0.13 to 0.6 wt.% FeO, preferably about 0.14 to 0.43 wt.%; greater than 200 to about 300 PPM CoO, preferably greater than 200 to about 250 PPM; about 5 to 70 PPM Se, preferably about 8 to 60 PPM; greater than 200 to about 300 PPM Cr_2O_3, preferably greater than 200 to about 250 PPM; and 0 to about 1 wt.% TiO_2, preferably about 0.02 to 0.5 wt.%. The glass compositions within this luminous transmittance range have a TSUV of no greater than about 35%, a TSIR of no greater than about 40%, and a TSET of no greater than about 45%.

In another embodiment of the invention, the green colored, infrared and ultraviolet radiation absorbing glass composition includes 0.9 to 1.3 wt.% total iron, preferably 1.083 to 1.11 wt.%; 0.25 to 0.40 wt.% FeO, preferably 0.306 to 0.35 wt.%; 80 to 130 PPM CoO, preferably 90 to 128 PPM; 8 to 15 PPM Se, preferably 10 to 12 PPM; 250 to 350 PPM Cr_2O_3, preferably 286 to 302 PPM; and 0.1 to 0.5 wt.% TiO_2, preferably 0.194 to 0.355 wt.%. These glasses have a luminous transmittance (LTA) of 25 to 40 percent, a total solar ultraviolet transmittance (TSUV) of about 25 percent or less, a total solar infrared transmittance (TSIR) of about 20 percent or less and a total solar energy transmittance (TSET) of about 30 percent or less.

It is expected that the spectral properties of the glass compositions disclosed herein will change after tempering the glass and further upon prolonged exposure to ultraviolet radiation, commonly referred to as solarization. In particular, it is believed that tempering and solarization of the glass compositions disclosed herein will increase the LTA and reduce the TSUV, TSIR and TSET. As a result, in one embodiment of the invention, a glass composition may have selected spectral properties that initially fall outside the desired ranges previously discussed but fall within the desired ranges after tempering and/or solarization.

Glass made by the float process typically ranges from a sheet thickness of about 1 millimeters to 10 millimeters. For vehicle glazing applications, it is preferred that the glass sheets having a composition and spectral properties as disclosed herein have a thickness within the range of 1.8 to 5 mm (0.071 to 0.197 inches). It is anticipated that when

using a single glass ply, the glass will be tempered, e.g. for an automotive side or rear window, and when multiple plies are used, the glass will be annealed and laminated together using a thermoplastic adhesive, such as polyvinyl butyral.

It is contemplated that vanadium may be used as a partial or complete replacement for the chromium in the glass compositions of the present inventions. More specifically, vanadium, which is expressed herein in terms of V_2O_5, imparts a yellow-green color to the glass and absorbs both ultraviolet and infrared radiation at different valence states. It is believed that Cr_2O_3 in the range of about 25 to 800 PPM discussed above may be completely replaced by about 0.01 to 0.32 wt.% V_2O_5.

As discussed earlier, other materials may also be added to the glass compositions disclosed herein to further reduce infrared and ultraviolet radiation transmission and/or control glass color. In particular, it is contemplated that the following materials may be added to the iron, cobalt, selenium, chromium and titanium containing soda-lime-silica glass disclosed herein:

MnO_2	0 to 0.5 wt.%
SnO_2	0 to 2 wt.%
ZnO	0 to 0.5 wt.%
Mo	0 to 0.015 wt.%
CeO_2	0 to 2 wt.%
NiO	0 to 0.1 wt.%

As should be appreciated, adjustments may have to be made to the basic iron, cobalt, selenium, chromium and/or titanium constituents to account for any coloring and/or redox affecting power of these additional materials.

Other variations as are known to those skilled in the art may be resorted to without departing from the scope of the invention as defined by the claims that follow.

Claims

1. A green colored, infrared and ultraviolet radiation absorbing glass article having a composition comprising a base glass portion comprising:

SiO_2	66 to 75 percent by weight,
Na_2O	10 to 20 percent by weight,
CaO	5 to 15 percent by weight,
MgO	0 to 5 percent by weight,
Al_2O_3	0 to 5 percent by weight,
K_2O	0 to 5 percent by weight,

and a solar radiation absorbing and colorant portion consisting essentially of:

total iron	0.60 to 4 percent by weight,
FeO	0.13 to 0.9 percent by weight,
CoO	40 to 500 PPM,
Se	5 to 70 PPM,
Cr_2O_3	15 to 800 PPM, and
TiO_2	0.02 to 1 percent by weight,

the glass having a luminous transmittance (LTA) of up to 60 percent at at least one thickness in the range of 1.8 to

5.0 mm.

2. A green colored, infrared and ultraviolet radiation absorbing glass article having a composition comprising a base glass portion comprising:

SiO_2	66 to 75 percent by weight,
Na_2O	10 to 20 percent by weight,
CaO	5 to 15 percent by weight,
MgO	0 to 5 percent by weight,
Al_2O_3	0 to 5 percent by weight,
K_2O	0 to 5 percent by weight,

and a solar radiation absorbing and colorant portion consisting essentially of:

total iron	1 to less than 1.4 percent by weight,
FeO	0.2 to 0.6 percent by weight,
CoO	greater than 200 to 500 PPM,
Se	5 to 70 PPM,
Cr_2O_3	greater than 200 to 800 PPM, and
TiO_2	0 to about 1 percent by weight,

the glass having a luminous transmittance (LTA) of up to 60 percent at at least one thickness in the range of 1.8 to 5.0 mm.

3. A green colored, infrared and ultraviolet radiation absorbing glass article having a composition comprising a base glass portion comprising:

SiO_2	66 to 75 percent by weight,
Na_2O	10 to 20 percent by weight,
CaO	5 to 15 percent by weight,
MgO	0 to 5 percent by weight,
Al_2O_3	0 to 5 percent by weight,
K_2O	0 to 5 percent by weight,

and a solar radiation absorbing and colorant portion consisting essentially of:

total iron	greater than 0.7 to 2 percent by weight,
FeO	0.13 to 0.6 percent by weight,
CoO	greater than 200 to 300 PPM,
Se	5 to 70 PPM,
Cr_2O_3	greater than 200 to 300 PPM, and
TiO_2	0 to 1 percent by weight,

the glass having a luminous transmittance (LTA) of 20 to 60 percent at a reference thickness of 4.06 mm.

4. A green colored, infrared and ultraviolet radiation absorbing glass article having a composition comprising a base glass portion comprising:

SiO_2	66 to 75 percent by weight,
Na_2O	10 to 20 percent by weight,
CaO	5 to 15 percent by weight,
MgO	0 to 5 percent by weight,
Al_2O_3	0 to 5 percent by weight,
K_2O	0 to 5 percent by weight,

and a solar radiation absorbing and colorant portion consisting essentially of:

total iron	0.9 to 1.3 percent by weight,
FeO	0.25 to 0.40 percent by weight,
CoO	80 to 130 PPM,
Se	8 to 15 PPM,
Cr_2O_3	250 to 350 PPM, and
TiO_2	0.1 to 0.5 percent by weight,

the glass having a luminous transmittance (LTA) of 25 to 40 percent at at least one thickness in the range of 1.8 to 5.0 mm.

5. A green colored, infrared and ultraviolet radiation absorbing glass article having a composition comprising a base glass portion comprising:

SiO_2	66 to 75 percent by weight,
Na_2O	10 to 20 percent by weight,
CaO	5 to 15 percent by weight,
MgO	0 to 5 percent by weight,
Al_2O_3	0 to 5 percent by weight,
K_2O	0 to 5 percent by weight,

and a solar radiation absorbing and colorant portion consisting essentially of:

total iron	0.6 to 4 percent by weight,
FeO	0.13 to 0.9 percent by weight,
CoO	40 to 500 PPM,
Se	5 to 70 PPM,
TiO_2	0.02 to 1 percent by weight,
Cr_2O_3	0 to 0.08 percent by weight,
V_2O_5	0 to 0.32 percent by weight,
MnO_2	0 to 0.5 percent by weight,
SnO_2	0 to 2 percent by weight,
ZnO	0 to 0.5 percent by weight,
Mo	0 to 0.015 percent by weight,
CeO_2	0 to 2 percent by weight,
NiO	0 to 0.1 percent by weight,

wherein the sum of the Cr_2O_3 concentration plus 25 percent of the V_2O_5 concentration is at least 0.0015 percent by weight, and the glass has a luminous transmittance (LTA) of up to 60 percent at at least one thickness in the range of 1.8 to 5.0 mm.

6. A green colored, infrared and ultraviolet radiation absorbing glass article having a composition comprising a base glass portion comprising:

SiO_2	66 to 75 percent by weight,
Na_2O	10 to 20 percent by weight,
CaO	5 to 15 percent by weight,
MgO	0 to 5 percent by weight,
Al_2O_3	0 to 5 percent by weight,
K_2O	0 to 5 percent by weight,

and a solar radiation absorbing and colorant portion consisting essentially of:

total iron	1 to less than 1.4 percent by weight,
FeO	0.2 to 0.6 percent by weight,
CoO	greater than 200 to 450 PPM,
Se	5 to 70 PPM,
TiO_2	0 to 1 percent by weight,
Cr_2O_3	0 to 0.08 percent by weight,
V_2O_5	0 to 0.32 percent by weight,
MnO_2	0 to 0.5 percent by weight,
SnO_2	0 to 2 percent by weight,
ZnO	0 to 0.5 percent by weight,
Mo	0 to 0.015 percent by weight,
CeO_2	0 to 2 percent by weight,
NiO	0 to 0.1 percent by weight,

wherein the sum of the Cr_2O_3 concentration plus 25 percent of the V_2O_5 concentration is at least 0.0200 percent by weight, and the glass has a luminous transmittance (LTA) of up to 60 percent at at least one thickness in the range of 1.8 to 5.0 mm.

7. The article as in claims 1, 2 or 3, wherein the glass has a redox of 0.2 to 0.4.

8. The article as in claims 1 or 2, wherein the glass has a total solar ultraviolet transmittance (TSUV) of 40 percent or less, a total solar infrared transmittance (TSIR) of 45 percent or less and a total solar energy transmittance (TSET) of 50 percent or less.

9. The article as in claims 3 or 8, wherein the glass has a total solar ultraviolet transmittance (TSUV) of 35 percent or less, a total solar infrared transmittance (TSIR) of 40 percent or less and a total solar energy transmittance (TSET) of 45 percent or less.

10. The article as in claims 1, 2 or 3, wherein the color of the glass is characterized by a dominant wavelength in the range of 480 to 565 nanometers and an excitation purity of no higher than 20 percent.

11. The article as in claim 10 wherein the color of the glass is characterized by a dominant wavelength in the range of 485 to 515 nanometers and an excitation purity of no higher than 10 percent.

12. The article as in claim 11, wherein the color of the glass is characterized by a dominant wavelength in the range of 490 to 510 nanometers and an excitation purity of no higher than 7 percent.

13. The article as in claim 10, wherein the color of the glass is characterized by a dominant wavelength in the range of 535 to 565 nanometers and an excitation purity of no higher than 10 percent.

14. The article as in claim 13, wherein the color of the glass is characterized by a dominant wavelength in the range of 540 to 560 nanometers and an excitation purity of no higher than 5 percent.

15. The article as in claims 1 or 2, wherein the glass has a luminous transmittance of less than 20 percent at at least one thickness in the range of 1.8 to 5.0 mm.

16. The article as in claims 1 or 2, wherein the glass has a luminous transmittance of 20 to 60 percent at at least one thickness in the range of 1.8 to 5.0 mm.

17. The article as in claim 2, wherein the FeO concentration is from 0.22 to 0.5 weight percent, the CoO concentration

is greater than 200 to 450 PPM, the Se concentration is 10 to 60 PPM, the Cr_2O_3 concentration is 250 to 400 PPM, and the TiO_2 concentration is 0.02 to 0.5 weight percent.

18. The article as in claim 17, wherein the FeO concentration is from 0.3 to 0.5 weight percent, the CoO concentration is greater than 200 to 350 PPM, the Se concentration is 35 to 50 PPM, and the Cr_2O_3 concentration is 250 to 350 PPM.

19. The article as in claim 17, wherein the glass has a total solar ultraviolet transmittance (TSUV) of 30 percent or less, a total solar infrared transmittance (TSIR) of 35 percent or less and a total solar energy transmittance (TSET) of 30 percent or less.

20. The article as in claim 19, wherein the glass has a total solar ultraviolet transmittance (TSUV) of 12 percent or less, a total solar infrared transmittance (TSIR) of 20 percent or less and a total solar energy transmittance (TSET) of 20 percent or less.

21. The article as in claim 2, wherein the FeO concentration is from 0.25 to 0.4 weight percent, the CoO concentration is greater than 200 to 250 PPM, the Se concentration is 10 to 30 PPM, the Cr_2O_3 concentration is greater than 200 to 250 PPM, and the TiO_2 concentration is 0.02 to 0.5 weight percent.

22. The article as in claim 21, wherein the glass has a total solar ultraviolet transmittance (TSUV) of 35 percent or less, a total solar infrared transmittance (TSIR) of 40 percent or less and a total solar energy transmittance (TSET) of 45 percent or less.

23. The article as in claim 22, wherein the glass has a total solar ultraviolet transmittance (TSUV) of 20 percent or less, a total solar infrared transmittance (TSIR) of 15 percent or less and a total solar energy transmittance (TSET) of 25 percent or less.

24. The article as in claim 3, wherein the total iron concentration is from 0.8 to 1.5 weight percent, the FeO concentration is from 0.14 to 0.43 weight percent, the CoO concentration is greater than 200 to 250 PPM, the Se concentration is 8 to 60 PPM, the Cr_2O_3 concentration is greater than 200 to 250 PPM, and the TiO_2 concentration is 0.02 to 0.5 weight percent.

25. The article as in claim 4, wherein the total iron concentration is from 1.083 to 1.11 weight percent, the FeO concentration is from 0.306 to 0.35 weight percent, the CoO concentration is 90 to 128 PPM, the Se concentration is 10 to 12 PPM, the Cr_2O_3 concentration is 286 to 302 PPM, and the TiO_2 concentration is 0.194 to 0.355 weight percent.

26. The article as in claim 25, wherein the glass has a total solar ultraviolet transmittance (TSUV) of 25 percent or less, a total solar infrared transmittance (TSIR) of 20 percent or less and a total solar energy transmittance (TSET) of 30 percent or less.

27. The article as in any of claims 1 to 26 comprising a flat glass sheet.

28. The article as in claim 27, wherein said sheet has traces of tin oxide in a surface portion.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 11 0335

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	GB 2 289 273 A (GLAVERBEL) 15 November 1995 * page 4, line 9 - page 7, line 8; examples *	1-28	C03C4/02 C03C4/08 C03C3/087
D	& CA 2 148 954 A		
D,A	EP 0 536 049 A (SAINT GOBAIN VITRAGE) 7 April 1993 * page 4, line 3 - line 32; examples 4,5 *	1-28	
D,A	US 5 023 210 A (KRUMWIEDE JOHN F ET AL) 11 June 1991 * column 3, line 3 - column 4, line 2; examples *	1-28	
D,A	US 4 104 076 A (PONS ANDRE) 1 August 1978 * column 2, line 67 - column 4, line 52; examples 3-7 *	1-28	
P,A	DE 196 36 303 A (GLAVERBEL) 13 March 1997 * page 3, line 38 - page 5, line 22; tables IIB,III *	1-28	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A	EP 0 653 388 A (PPG INDUSTRIES INC) 17 May 1995 * page 2, line 37 - page 3, line 44; tables * * page 8, line 48 - line 53 *	1-28	C03C
D,A	EP 0 705 800 A (ASAHI GLASS CO LTD) 10 April 1996 * the whole document *	1-28	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17 October 1997	Van Bommel, L

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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